Development of high-temperature superconducting REBCO coils for ECR ion sources

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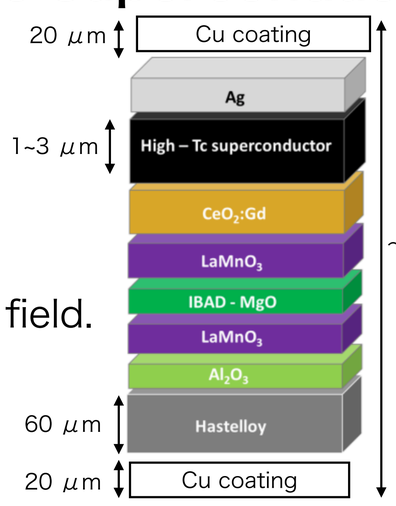
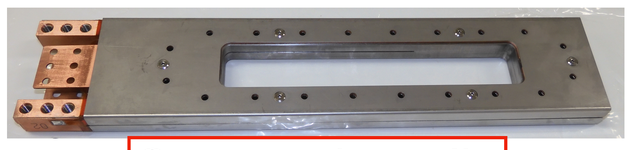
REBCO coils for ECR ion sources

Second Generation High Temperature Superconductor (HTS) Tapes

Product of SuperOx Japan

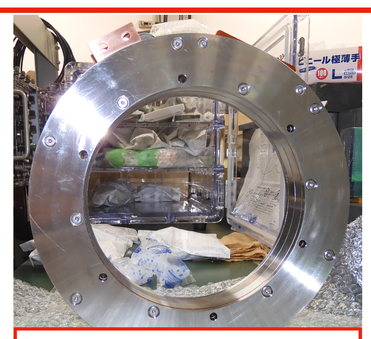
- $REBa_2Cu_3O_{7-x}$ (REBCO, RE=rare earth), rare earth barium copper oxide.
- $T_c > 90K$
- High Current density in high transverse magnetic field.
- $J_c > 10{,}000 \frac{A}{mm^2}$ under 20T transverse B-field, 30K





Sextupole coils

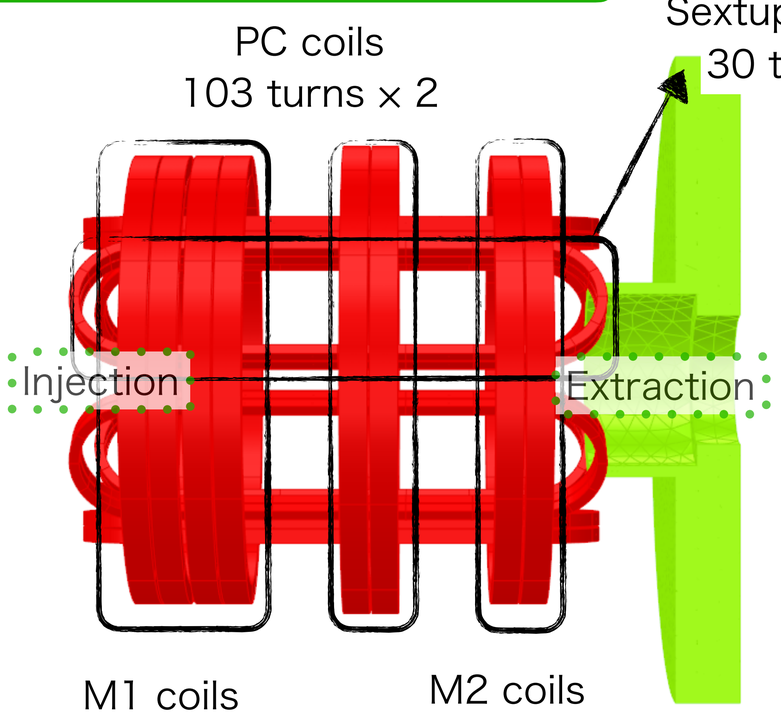
- Width : 6 mm
- Bending radius : 25 mm
- I_c > 250 A at 30 K
- No Insulation windings.



Solenoid coils

- Width : 12 mm
- Internal diameter~190 mm
- I_c > 500 A at 30 K
- Metal Insulation windings.

REBCO coils configuration



- Production : proton, deuteron, helium ion beams.
- Cooled by GM cooler.
- Operate at: 20 K~30 K
- Operate at 2.45 GHz and 10 GHz

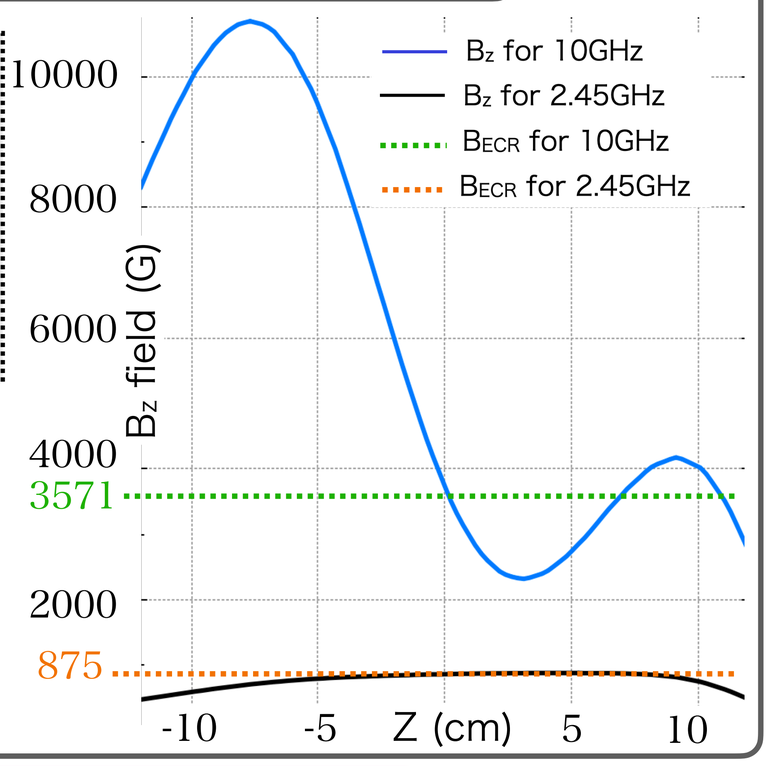
B-field configuration (2.45 GHz and 10 GHz mode)

Mirror ratio (10 GHz,500 A)

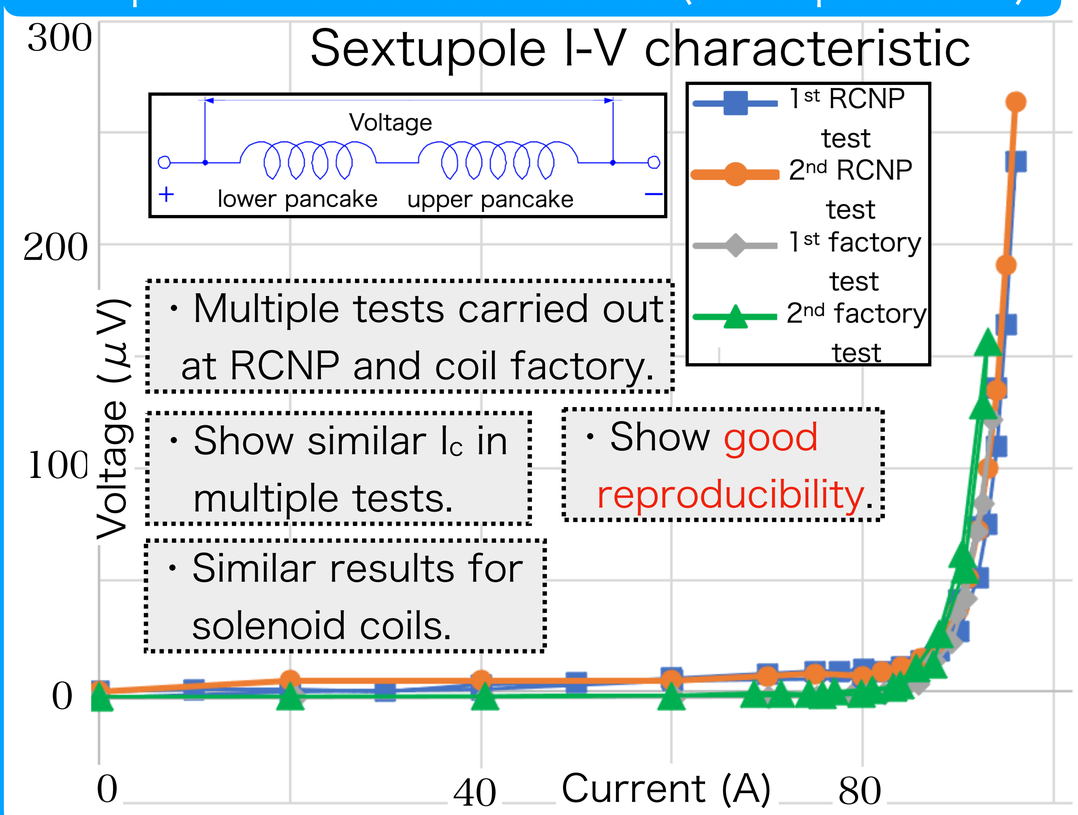
$$\frac{B_{inj}}{B_{ECR}} \sim 3, \frac{B_{ext}}{B_{ECR}} \sim 1.2,$$

$$\frac{B_{min}}{B_{ECR}} \sim 0.65, \frac{B_{rad}}{B_{ECR}} \sim 2$$

- Min-B configuration for 10 GHz operation.
- No mirror field for 2.45 GHz operation.

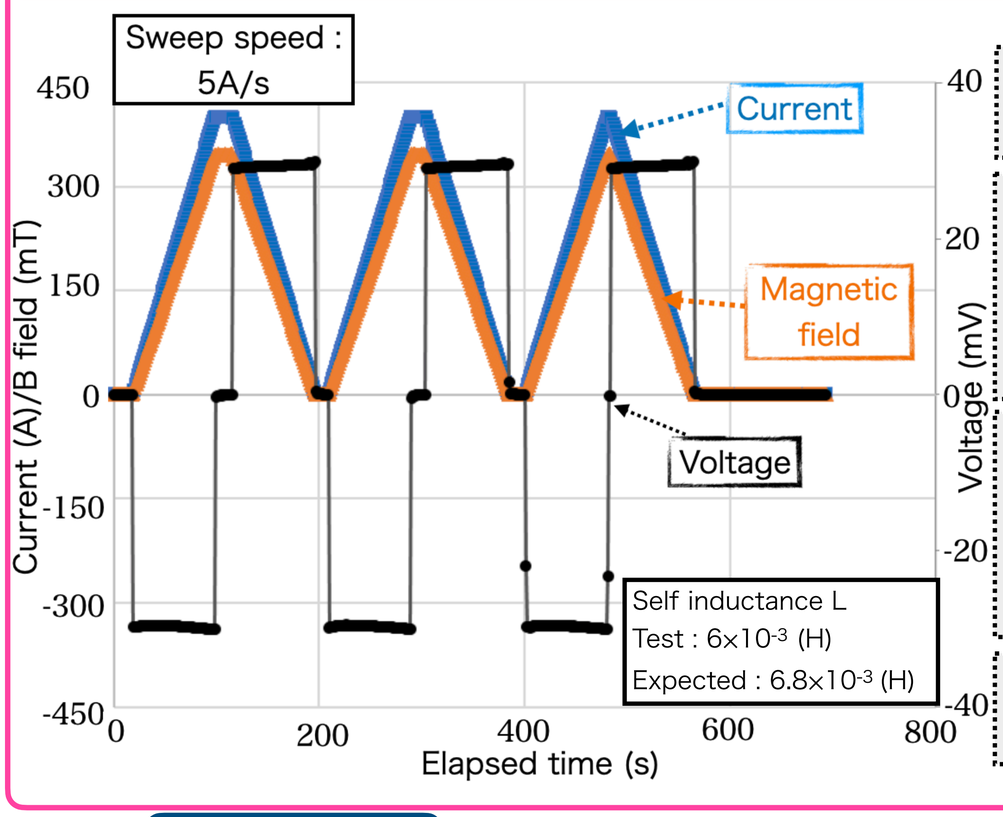


77K performance test results (Sextupole coils)



- Multiple tests carried out at RCNP and coil factory.
- Show similar I_c in multiple tests.
- Show good reproducibility.
- Similar results for solenoid coils.

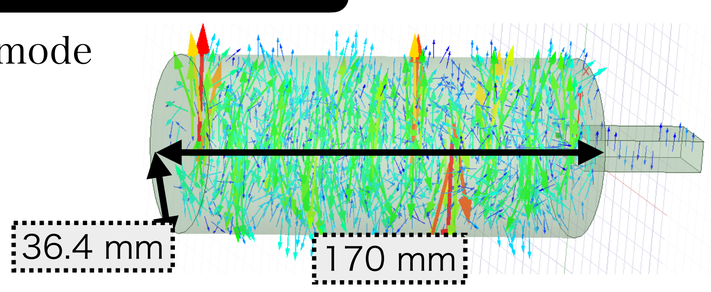
31K performance test results (Solenoid coils,M2)



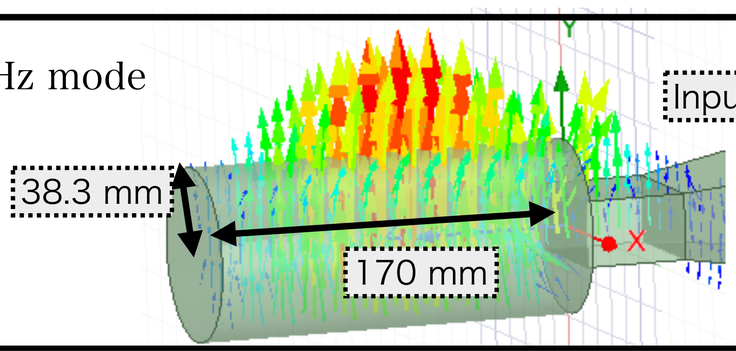
- Multiple tests done inside cryostat, 31 K.
- No voltage increase due to normal conducting state transition.
- Show High reliability and reproducibility of magnetic field induction.
- Similar results for sextupole.

rf modes calculation

10 GHz mode



2.45 GHz mode



Conclusion

- REBCO solenoids and sextuploes has been constructed, performance tests showed good reliability and reproducibility.
- We intend to construct the HTS-ECR and carry out performance tests for a longer elapsed time in next year.
- Magnetic field and electric field configuration has been designed for HTS-ECR.
- HTS-ECR made by REBCO coils is expected to be capable of producing electron, He^{2+} ion or even heavy ion.